shows that it is of the chondriform type, being developed in a thick leathery periosteum of fibro-cartilage, and which appears to be continuous with the true cartilage wherever the two come into contact.

It is not possible to give any definite idea of the detailed observations contained in a memoir of which so large a portion is devoted to minute investigation. The inferences which the author deduces from his facts are given in connexion with each of the several topics discussed; and in the concluding portion of the memoir he points out the bearing which they have upon some general questions in physiology. A close resemblance is shown to exist between the processes of calcification, as carried on in the fibrous tissues of fish-scales, in cartilages and in fibro-cartilages, in all of which the phænomena closely correspond; and the author thinks that the bones and teeth of mammals, in which the process is far less obvious than in these ichthyal structures, may be calcified in a similar way.

The important bearing of the membraniform kosmine structures (which closely resemble the different varieties of dentine) upon the generally received hypothesis respecting the growth of teeth is also discussed; and the author thinks there are such sufficient reasons for doubting the correctness of that hypothesis, as to render a review of the evidence upon which it is based very desirable.

The peculiar modifications which the homologues of the Haversian canals of anthropotomists present amongst different groups of fishes are pointed out, as well as the very near affinity which exists between bone, dentine, ganoin, kosmine, enamel; and the probability of a closer relationship between cartilage, fibro-cartilage and fibrous periosteum, is also suggested as a subject deserving further investigation. The field opened out to the physiologist and the microscopist in the department of ichthyology is almost boundless, being comparatively unexplored, whilst it promises a rich harvest to those who labour in it.

7. "On the Impregnation of the Ovum in the Amphibia." By George Newport, F.R.S., F.L.S. &c.

The author states that this communication to the Royal Society is part of a series of investigations on development, on which he has been for some years engaged, and which was commenced in a paper on that of the Myriapoda, published in 1841, in the Philosophical Transactions. The plan followed in these investigations has been to combine observations on the natural history of the animals with others on the conditions which affect their development, as the best mode of arriving at correct conclusions. The history of the discovery of what can now be proved to be the direct agent of impregnation, the spermatozoon, is then traced; and it is shown, that although within the last few years an opinion has been gaining ground that the spermatozoon, and not the *liquor seminis*, as formerly supposed, is the means of impregnation, no acknowledged proof has hitherto been given of the correctness of this opinion, and no refutation afforded to the theory that the *liquor seminis* is the part of the seminal fluid immediately concerned. The question of

the agency of the spermatozoon has thus remained open; and it is to this question, with a view first to supply proof from direct experiments of the fact of the agency of this body, as well as to examine into the circumstances under which this agency is exerted, influenced or impeded, that the present communication is especially devoted.

The author then traces the changes in the ovum within the body of the Amphibia, from a short time before the disappearance of the germinal vesicle to the period when the ovum is expelled before impregnation. The structure of the germinal vesicle in the ovarian ovum is shown to be an involution of cells, as stated by Wagner and Barry; but the author differs entirely from the latter respecting the mode of disappearance of the vesicle, and also respecting the part played by its constituents in the production of the embryo. He believes the included cells are liberated by the diffluence of the membrane of the germinal vesicle in the interior of the yelk, not in the centre of the yelk, but much nearer to the upper or dark surface than to the white or inferior, and at the bottom of a short canal, the entrance to which is in the middle of the upper or black surface at a point already noticed by Prevost and Dumas, Rusconi and Böa; and he thinks that it is due to the diffluence of the envelope of the vesicle in this situation that the moment of disappearance has not yet been observed. The germinal vesicle in the Amphibia always disappears before the ovum leaves the ovary, and escapes into the cavity of the abdomen. The mode in which the ovum, after leaving the ovary, is believed to arrive at the entrance of the oviduct is then stated, and the structure of the entrance in the intermedial space, as shown by Swammerdam, described.

The author then traces the changes in the impregnated and in the unimpregnated ovum after spawning, from the first minute to the segmentation of the yelk in the former, and shows that the appearances in the two are almost identical during the first ten or twelve minutes, but that after that time the changes in the unimpregnated ovum cease, while further changes take place in the impregnated. The yelk at the end of from twelve to fifteen minutes invariably then rotates, so that the dark surface becomes uppermost; and it constantly afterwards returns to this position, however much or frequently this may be changed. In about three hours the yelk becomes separated on the upper surface from the vitelline membrane, and a space or chamber is formed between the two. The yelk then becomes depressed on the upper surface, but is slightly elongated to an obtuse oval form, in the horizontal direction; and in about half or three-quarters of an hour afterwards begins to divide in the margin of the central spot or orifice, from which point the division, as already known, passes outwardly and around the yelk until the mass is divided into two portions. These changes do not take place in the unimpregnated ovum, which merely becomes somewhat oval, but does not divide; so that segmentation may be regarded as a proof that the egg has been impregnated, a fact that was of great use as a test in the following experiments. The susceptibility of the ovum to become impregnated, and the circum-

stances which affect this, are then shown to depend on the degree of expansion of the envelopes, the imbibition of fluid, the temperature of the surrounding medium, and the degree of aëration. The envelopes expand and imbibe fluid most rapidly during the first half hour after the egg has been laid, and the susceptibility is diminished in the inverse ratio of the expansion and imbibition. It is greatest during the first three minutes, but is very feeble at the end of half an hour. These conditions are greatly modified by temperature, and in a much less degree by the aëration of the ovum. Experiments in proof of these facts are detailed, especially with reference to the number of eggs segmented and of embryo produced, and their earlier or later appearance in proportion to the higher or lower temperature of the medium. In March 1849 the author put to the test the agency of the spermatozoa in impregnation, by an experiment long since employed by Spallanzani, and more recently by Prevost and Dumas, namely, by carefully separating the spermatozoa of the Frog from the *liquor seminis* by filtration, and employing these, with the filter-paper on which they had been collected, in experiments on some sets of eggs, and the liquor in others; and the result was, that almost every ovum became impregnated in the former, but scarcely a single ovum in the latter. The production of a very few embryos in the sets to which the *liquor seminis* was added, he attributes to the fact that the whole of the spermatozoa had not been removed. These experiments he has repeated during the present spring with still more decided results; not a single ovum becoming segmented, nor a single embryo produced when the *liquor seminis* was completely freed of spermatozoa. The author states that these experiments had been completed, and he was engaged in preparing the paper for presentation to the Royal Society, before he was aware that the physiologists above named, Spallanzani first, and afterwards Prevost and Dumas, had obtained similar results by filtration of frog's semen, although the fact of their observations has been almost overlooked. To them therefore he resigns the credit of the results; but as his own investigations have been so completely independent of theirs, from which also they differ in some respects, he has felt it to be desirable still to give them in detail in this paper.

The direct agency of the spermatozoa in impregnation being thus proved, the author proceeds to investigate its nature. He first shows that the ova are not impregnated after the motive power in the spermatozoa has ceased. The period of duration of this power he finds to be much shorter than supposed by Spallanzani and by Prevost and Dumas; and he attributes the difference in length of time as observed by these authors and himself, to their having adopted the objectionable mode of procuring the seminal fluid by vivisection from the testes as well as the vesicular seminales, by which he conceives that spermatorial cells were obtained as well as mature spermatozoa, and that the former became matured only at a late period of the experiments. He differs also from Prevost and Dumas, and Dr. Martin Barry, with regard to the supposed pene-

tration of the spermatozoon bodily into the ovum. All the observations he has been able to make on the ovum of the Frog, both microscopically and experimentally, are opposed to the belief that any fissure or perforation exists in the envelopes of the ovum, as described by Dr. Barry in the ovum of the Rabbit, and through which the spermatozoon was supposed to enter. Neither is he able to confirm the statements of Prevost and Dumas, that the spermatozoa penetrate into the substance of the envelope of the egg either of the Frog or the Newt; and he thinks these distinguished observers must have supposed that spermatozoa which they saw on the exterior of the ovum were in the interior. The author has put this question to the test in the ovum of the Newt, *Lissotriton punctatus*. He extracted an ovum, which he had reason to believe had not been impregnated, from the oviduct, and placed it with seminal fluid in water, and immediately afterwards examined it with the microscope. Spermatozoa were detected upon it in less than one minute after immersion; but neither then, nor at any subsequent period, could even a single spermatozoon be seen within it, although the whole interior of the egg was brought within focus of the microscope, and distinctly recognised. This egg was preserved in a small glass capsule beneath the microscope, and watched until the embryo was produced. Spermatozoa were recognised on the exterior during the first forty-eight hours.

But although spermatozoa do not enter the interior, they are invariably found in contact with the surface of the impregnated ovum, and this contact is essential to their agency. The author also shows that the envelopes of the ovum are essential to its fecundation, and that ova taken from the ovary, or from the cavity of the body after they have left the ovary, but have not yet entered the oviduct and acquired their gelatinous coverings, are not susceptible of being impregnated. The coverings imbibe water by endosmose, but do not usually admit solid particles of matter equal in size to spermatozoa into their texture, as was proved by immersion in solution of carmine.

The author then enters at length on an examination of the agency of the spermatozoa as affected by chemical media. Availing himself of a fact ascertained during a chemical analysis of seminal fluid by Dr. Frerichs, that the spermatozoa are decomposed by caustic potash, he conceived the possibility of so employing this agent as to render it a test in experiment. Ova were passed from the body of a frog on a dry surface, without being in contact with water, until seminal fluid mixed with it was applied to them. After the lapse of a given time, solution of caustic potash, of sufficient strength to decompose the spermatozoa immediately, was also applied, and as quickly as possible afterwards was again diluted and removed with water, before the potash, as found by other experiments, acted prejudicially on the ova. The result was that segmentation of the yelk usually took place even when the interval of time between the application of the seminal fluid and the solution of potash was only one or two seconds, but no embryos were produced. When, however, the interval was five seconds, a very few embryos were formed;

but when the interval was fifteen or more seconds, they were produced in greater number. The conclusion deduced from these and similar experiments with nitrate of potash was, that impregnation is commenced almost at the instant of contact of the spermatozoon with the ovum; but that duration of contact, and possibly also diffluence of the spermatozoon and endosmosis of its substance, is necessary for fruitful impregnation. The experiments were varied by the application of the solution of potash before that of the seminal fluid, in which case the results were more unfavourable. With nitrate of potash, applied before as well as after the seminal fluid, the formation of embryos was not unfrequent. None however were produced when diluted acetic acid was used. This acid acts quickly and most unfavourably on the envelopes of the ovum.

The agency of the impregnating bodies was then tested in a similar way, by the application of solutions of gum-arabic and of starch, the action of which is merely mechanical. The results were similar to those with the potash.

When the gum or starch was applied, as in the case of the potash, *after* the application of seminal fluid in water, embryos were constantly produced, even when the interval between the two applications was only one second; but when either of these was applied to the ovum *before* the seminal fluid, then segmentation, if it occurred at all, took place very tardily. In general, however, no segmentation occurred, and no embryos, or but very few indeed, were produced.

These experiments, compared with those with potash, seemed to show that impregnation is commenced in a very short space of time, and that the spermatozoon is the agent immediately concerned; and that this agency is material in its operation, as seems to be shown in the fact that it can be prevented by the application both of chemical and of mechanical means to the ovum. We are thus led to infer, that although the spermatozoon does not bodily penetrate into the ovum, its first effect may have some relation to catalytic action, in inducing the segmentation of the yelk; and, having proof that fluids permeate the coverings of the ovum, we may hereafter find that the process is completed by the diffluence of the impregnating body, and the substance into which it is dissolved, by imbibition into the ovum by endosmosis.

One plate of the structures described accompanies the paper.

8. "A Mathematical Theory of Magnetism." By William Thomson, Esq., M.A., F.R.S.E., Fellow of St. Peter's College, Cambridge, and Professor of Natural Philosophy in the University of Glasgow.

The Theory of Magnetism was first mathematically treated in a complete form by Poisson. Brief sketches of his theory, with some simplifications, have been given by Green and Murphy in their works on Electricity and Magnetism. In all these writings a hypothesis of two magnetic fluids has been adopted, and strictly adhered to throughout. No physical evidence can be adduced in support of such a hypothesis; but, on the contrary, recent discoveries, especially in electro-magnetism, render it excessively improbable. Hence it is